WEST AFRICAN CACAO RESEARCH INSTITUTE

QUARTERLY PROGRESS REPORT

No. 38

TAFO, GOLD COAST.

COMMONWEALTH MYCOLOGICAL INSTITUTE
18 AUG 1955

WEST AFRICAN COCOA RESEARCH INSTITUTE
TAFO

THIRTY-EIGHTH QUARTERLY REPORT : APRIL-JUNE, 1955

SENIOR STAFF

Director	:	(vacant)
Deputy Director	:	A. Pickles (Acting Director) (on leave 10th April to 8th June)
Secretary	:	G. H. Neal
Maintenance Engineer	:	C. Alderson, D.S.O. (on leave)

TAFO STATION

Division of Entomology	:	H. R. Mapother F. Raw D. J. Taylor (on leave 6th April) P. B. Cornwell F. E. Decker
Division of Pathology	:	W. T. Dale (on leave 29th May) T. W. Tinsley (on leave) A. L. Wharton G. Usher (on leave) A. Attafuah (appointed 1st April)
Division of Botany	:	J. F. Archibald (on leave) H. H. Rogers (on leave 11th May) R. Knight (on leave) A. D. McKelvie (returned 6th April)
Division of Soil Science and Chemistry	:	S. N. Adams E. Margaret Holden T. A. Rohan (arrived 17th May)
Division of Agronomy	:	R. J. Benstead R. Wickens
Station Manager	:	S. E. Ntim-Kwafo (on leave 12th April)

IBADAN SUB-STATION

Acting Officer-in-charge	:	J. Nicol
Entomologist	:	R. G. Donald (on leave 5th May)
Pathologists	:	R. M. Lister J. M. Thresh (on leave 3rd June)

STAFF .../

STAFF MATTERS

Mr. Pickles was on leave for eight weeks during the quarter and Mr. W.T. Dale acted as Director during his absence.

Mr. H.H. Rogers went on final home leave in May, prior to assuming duty at the Plant Breeding Institute, Cambridge.

Mr. H.R. Mapother visited the substation at Ibadan to advise on methods and machines suitable for insect control under the conditions of cacao cultivation common in Nigeria. Mr. J.M. Thresh made an extensive tour in the Cameroons to look for possible wild hosts of swollen-shoot virus.

VISITORS

His Excellency the Acting Governor, accompanied by the Regional Officer, Eastern Region visited the Institute in May. Other visitors included Mr. R.L. Fowler of Foreign Operations Administration, Brazil and Dr. H.L. Penman, head of the Physics Department, Rothamsted Experimental Station. Mr. C. Eastwood of the Colonial Office visited the substation at Ibadan.

MANAGEMENT AND MAINTENANCE

The Capsid laboratory and Rest House Extension were completed. Work on the extension of W.A.C.R.I. Club House was well on the way to completion by the end of June and repairs to the old section, including re-roofing and renewal of weak timbers, were completed.

A contract has been drawn up for the construction of the new laboratory building at Ibadan.

The average daily production and consumption of water was as follows :-

	Production	Consumption
April ...	22,423 gallons	21,566 gallons
May ...	21,477 "	18,380 "
June ...	18,745 "	17,633 "

All samples of water submitted for analysis were reported free from contamination.

CROP DELIVERY

Harvesting of the Minor Crop started on June 6th and of the 6,468 pods harvested 6.6% have been discarded as unfit for fermentation.

There is a good showing of pods on the trees for the Main Crop.

SWOLLEN .../

SWOLLEN SHOOT DISEASE

Re-inspection and treatment for Swollen Shoot Disease disclosed a higher rate of infection than in the previous quarter at all stations except Nankese which remains free from disease.

The data is tabulated below -

Stations	April	May	June	Total
Old Station	77	49	25	151
Square Mile x	268	264	339	872
Adonkwanta	15	9	21	45
Akwadum	0	1	0	1
Nankese	0	0	0	0
Kukua	0	3	3	6
Koransang	0	1	12	13

x Includes Contacts and Suspects.

Nineteen diseased seedlings were found on the Old Station replantings but none in squared off experimental areas.

OUT-STATIONS

The cacao and shade trees have been again thinned where necessary and on all stations this appears to have increased pod-setting.

There are good crop prospects throughout. Capsid damage has been light and kept well under control.

RAINFALL

The monthly rainfall for all the Institute's observation stations is given in the following table -

Station	Rainfall in inches				Wet days			
	April	May	June	Total	April	May	June	Total
Tafo	3.19	6.98	10.49	20.66	10	17	22	49
" (17-yr. mean)	5.81	6.93	8.43	21.17	11.2	13.5	18.4	43.1
Adonkwanta	4.65	7.25	10.40	22.30	9	13	11	33
Akwadum	5.66	7.14	16.29	29.09	10	15	22	47
Nankese	4.36	5.59	11.61	21.56	8	15	17	40
Kukua	7.35	3.12	10.32	20.89	10	10	10	30
Koransang	8.90	3.01	13.05	24.96	10	9	10	29

TAFO .../

TAFO STATION

1. VIRUS RESEARCH

(a) Host Range of Cacao Viruses

The survey of the distribution of Adansonia digitata L. in the Gold Coast is continuing. No virus-infected specimens have yet been found in the cacao areas. The infections at Wasipe and Yabrasu remain the most northerly of those detected so far; material collected from Bawku has given no evidence of infection.

Surveying for viruses in other members of the Tiliales, with particular emphasis on Sterculia rhinopetala K. Schum., is continuing. No natural infections have been detected in hosts other than Adansonia digitata and Cola chlamydantha K. Schum. since those reported by Posnette, Robertson and Todd (Ann. appl. Biol., 37, p.229, 1950) in Ceiba pentandra Gaertn. and Cola gigantea var. glabrescens Brenan and Keay.

Heliocarpus popayanensis (Tiliaceae), a plant which does not occur in the Gold Coast, has proved susceptible to the New Juaben cacao virus. It reacted with leaf-crinkling and slight localized vein-banding of the leaves. Seed was obtained from Trinidad, where the plant is fairly common in the Northern Range, and it would be interesting to know if it is susceptible to the cacao virus which occurs there.

(b) Insect Transmission Studies - New Juaben Virus

Results recorded in the 37th Quarterly Report suggested that "crawlers" and young adults of Pseudococcus njalensis Laing are comparable in efficiency as vectors. They did not support the earlier belief that equivalent infection rates are obtainable with either ten adults or thirty crawlers; but it was felt that this ratio might hold good when the vectors were manipulated by relatively unskilled operators, which would lead to a bias in favour of the larger and more robust adults. Two experiments were therefore arranged, using Assistant-grade virus transmitters, some of whom had limited experience. In both experiments source- and test-feeding times were at the presumed optimum, and the insects were pre-starved. The virus source plants in the first experiment were cacao seedlings in the first-flush stage, and two young adults were compared with six crawlers. All three operators obtained a higher infection rate with the latter, the combined figures being 75 and 95% respectively. In the second experiment, cacao seedlings in the second- or third-flush stage were the source plants, and five young adults were compared with fifteen crawlers. Three of the four operators obtained better results with the latter, and the infection rates were 26 and 61% respectively.

(c) Classification of Viruses and Virus Strains

It is not yet possible to say whether the Adansonia virus AD.7 is related to the cacao virus from Kpeve. The similarity between their symptoms is such that it is difficult to decide whether the former has inhibited the latter in protection tests. The same problem exists with isolates from Cola chlamydantha and some Western Province cacao strains.

Studies .../

Studies were resumed some months ago on mild-strain protection in the New Juaben virus complex. Thirty-six plants were infected in the bean stage with a mild strain, and following the development of transitory mild symptoms they have been "bombarded" at monthly intervals with a virulent strain, using single adult mealybugs (in an attempt to approximate to conditions in a field outbreak). An equal number of "unprotected" seedlings have been similarly treated. Fourteen of the latter have shown virulent symptoms, but none of the former have done so. However, when "back-tests" with single mealybugs were made from the "protected" plants after six bombardments, some of the test plants from six of them yielded virulent strains as well as mild ones.

(d) Attempted Mechanical Transmission

Experiments have been continued using as inoculum extracts from mature cacao leaves and from seedlings of several other species infected with the New Juaben strain of the virus. Cysteine hydrochloride and thiomalic acid have been used as reducing agents to prevent oxidative changes in the extracts. The test plants used included seedling cacao and Adansonia digitata and also cowpea and French bean seedlings.

(e) Effect of Nutrition on Infection with the New Juaben Virus

Experiment V, which included eight nutritional treatments, has been harvested and the final data collected for assessment.

(f) Chemical Detection of Virus Infection

The retesting of the Trinidad Introductions has been concluded. Of the 302 trees in the 10 selections which were tested on both occasions 92 (30%) gave an identical score in the Tinsley-Usher colour test. Of the remainder two-thirds gave a higher and one-third a lower score when tested the second time. The scoring differed by 2 or more points, on a 6 point scale, in nearly half of these.

The retesting of a number of trees which had given a high score in the colour test, but had shown no symptoms at the time of testing and had developed none since, was also concluded. Out of the 47 trees 26 gave a high score similar to that of leaves known to be infected, 7 gave a low score and the remaining 13 gave an intermediate value.

Paper partition chromatography has been used to separate the polyphenols and "flavones" in extracts of cacao leaves. Particular attention has been paid to the "flavones" as many of these compounds give a red colour on treatment with alkali. There was therefore the possibility that the colour test was due to this. Extracts were made either by grinding fresh leaves in dilute acid and clarifying the solution thus obtained, or by methanol extraction of dried material. The most satisfactory separations so far have been with dilute acid extracts run with the alcohol layer of a butanol-acetic acid - water mixture (4 : 1 : 5). "Flavones" can be detected on the papers by the yellow colour they give with ammonia vapour. The position of the substance responsible for giving a red colour on heating with alkali has been located and does not correspond with that of any of the numerous "flavones" present.

(h) .../

(b) Resistance to the New Juaben Virus

It is most unlikely that immunity to this virus exists in Iquitos-type cacao (T17) though there is often quite marked resistance to infection and varying tolerance.

Of 123 plants (including four Amelonado controls) that were apparently virus-free after "bombardment" as dissected beans (see 35th Quarterly Report), only three are still symptomless after a second bombardment with 200 infective "crawlers" per plant (an unduly large number as it now appears). The three "survivors", representatives of the crosses 1072 x 433, 1131 x 1157 and 1131 x 1220, will be "back-tested" soon for latent infection.

The "twinned" plants (36th Quarterly Report), which were given their initial bombardment with 150 infective crawlers 5 or 6 months ago, have reacted as follows -

Progeny	Plants tested	Symptom rating				
		1	2	3	4	5
T17 :-						
1070 x 434	48	20	11	10	3	4
1070 x 447	38	6	16	10	5	1
1131 x 1217	31	6	11	6	3	5
1072 x 521	40	1	9	19	11	0
W B E 980	31	12	17	2	0	0
Amelonado controls (total)	83	Unclassified: in general more severe than 1.				2

1 = severe - approaching Amelonado rating;

2 = intermediate;

3 = mild;

4 = almost undetectable or evanescent;

5 = nil - "back testing" in progress.

By bulking and testing appropriate uninfested "twins" it is hoped to find out whether there are real differences within and between the T17 progenies as regards resistance and tolerance, and whether these characteristics are correlated. The availability to vectors of virus in seedlings showing different degrees of tolerance will also be tested.

An experiment has now been started to compare resistance in rooted cuttings from a number of Iquitos-type trees, some of them parents of the seedlings already tested.

2. .../

2. MEALYBUG STUDIES

(a) Movement of Mealybugs in the Canopy

A study of the movement of mealybugs on individual cacao trees by a method outlined in the previous report has continued. During a period of 47 days, 269 mobile mealybugs were caught on four living trees supporting high mealybug populations. Also, 42 mealybugs were caught on four dead trees adjacent to, but not touching the living trees; these mealybugs must have been carried by wind. A further 202 mobile insects were recorded on eight living trees during a period of 20 days. Identification of the various instars showed that 88% of the mobile insects were first instar nymphs, 9% were second instar, and the third instar and adults together constituted 3%.

Wind and temperature measurements have been studied in relation to the extent of mealybug movement; disturbance of the branches by wind currents appears to have no effect in initiating movement. The numbers of insects recorded over 5-day periods is closely related to the mean 9.0 a.m. temperature.

(b) Aerial Dispersal Studies

All experiments described in previous reports have been continued. Numbers of insects recorded on sticky traps have been extremely low. The establishment of windborne mealybugs on seedlings appears to be related to the degree of insolation. Changes in the numbers of insects caught on different seedlings traps on the W.A.C.R.I. reservoir show some relationship to changes in wind direction.

(c) Variation in Mealybug Populations

Data obtained from the survey previously reported has been collated and the results have been prepared for publication.

(f) Mass-breeding of Mealybugs

In connection with bionomical studies and virus research large quantities of mealybugs are required in both the Gold Coast and Nigeria. The existing method of obtaining supplies from field collections does not adequately satisfy requirements. Therefore the need for evolving a method for the mass-breeding of mealybugs has become extremely urgent.

As a preliminary to the development of a successful technique for bulk rearing of the bugs a "culturing" room has been built in which an attempt is being made to maintain a constant high relative humidity approximating to field conditions. Temperature readings have shown that a constant temperature of 84°F and 95% humidity can be maintained over a fairly long period.

Rapid germination of cacao beans has been obtained under these conditions and further studies are intended, using other host plants. The behaviour of both mealybugs and ants will be ascertained.

3. .../

3. STUDIES ON BLACK POD DISEASE

(a) Fungicide Control Trials

A considerable number of pods have been harvested already on Trial I and the main categories can be briefly summarized as follows :-

Treatment	PODS PER TREE								
	Total	Damaged	% *	'Black-pods'	% *	'Rodent'	% *	Other-wise Damaged	% *
Control (unsprayed)	6.93	4.24	61.2	0.76	11.0	2.54	36.7	0.93	13.4
'Carbide-Bordeaux'	5.32	3.11	58.5	0.18	3.4	2.15	40.4	0.78	14.7
Bordeaux Mixture	9.96	5.80	58.2	0.38	3.8	4.02	40.4	1.40	14.1
'Perenox'	5.20	3.02	58.1	0.14	2.7	2.35	45.2	0.53	10.2

* Classified pods as a percentage of total pods harvested.

Few "black pods" have been recorded for all the fungicide treatments but the control figures are also low for the time of year. It is too early to say if this represents a seasonal drop, or a possible overall reduction of disease on Bunso Plantations due to spraying treatments, which, in some cocoa areas, are now entering the third year. Rainfall figures for June are expected to be average. The mean number of black pod infections recorded for this period last year, when spraying treatments began, was 35% of the total pods harvested compared with 5% this year.

It is unfortunate that large numbers of damaged and discarded pods are still being recorded, despite the low incidence of black pod disease. This can be attributed to the depredations of rodents, as many as 45% of all pods harvested on the "Perenox" plots being attacked by these pests. The question of whether pod losses due to rodents have increased, following a reduction in black pod disease, will have to be considered. Less rodent damage is recorded from weekly harvested plots than from monthly harvested.

Air temperature and humidity recording instruments have been set up on the trial, for examination of any correlation between these two factors and incidence of disease. Early morning temperatures for each of the last six weeks have averaged 68 to 69°F and there has been a progressive lengthening in the period of the day during which air humidity remains high.

The trial has suffered considerably during the quarter from tree losses due to "swollen shoot" and storm damage.

The crop season is later on Trial II and few pods have been harvested. Less disease has been recorded than last year but losses due to rodent attacks are high.

(c) .../

(c) Cushion Infection

The problem of how many of the proximal black pod infections recorded previously on Trial 1 can be attributed to black pod disease originating from infected cushions is being studied on 72 trees, included in six spare control plots. All accessible pods are being brush-painted weekly, with a strong fungicidal paste, with the object of completely preventing any infections from germinating spores. Any proximal infections recorded this year may then be attributed to the fungus spreading internally from the cushions. Treated pods and untreated, innaccessible pods in the canopy are being recorded separately.

Various methods have been tried for fixing tubes of molten nutrient media to trees, with a view to isolating Phytophthora palmivora Butl. from diseased tissues in situ. The first object was to ensure that the tubes remained free from contamination with other non-pathogenic fungi. Surface sterilising of the bark with absolute alcohol, before fixing on the tubes with plasticine, was the most effective of the methods tried, but others are being repeated. Many tubes quickly became overgrown with the ubiquitous Botryodiplodia theobromae, Pat. which masked the growth of other fungi. The use of other media in the tubes may help to prevent this.

All old cushions on a small number of cocoa trees are being cut off to find out if a tree will regenerate new cushions when the existing ones are removed.

(d) Assessment of Losses due to Black Pod Disease in the Gold Coast

The Department of Agriculture has made available the harvest records for the 1954/55 crop season from cocoa stations, and field trials on farmers' cocoa, scattered through Ashanti and the Eastern Region. Details extracted from them should provide information about losses due to black pod disease on cocoa stations and farmers' cocoa and also the potential loss of crop under farmers' methods of harvesting. More complete records are being taken this year including the classification of diseased ripe pods as well as diseased unripe.

4. CAPSID STUDIES

(a) Capsid Pocket Regeneration Experiments

These experiments are now being laid down. The treatments under investigation are :-

Uncoppiced Trees

(1) Regular spraying with 2.5% DDT emulsion.
(2) Untreated trees.

Coppiced Trees

(1) Wet season coppicing (June), light shade.
(2) Wet season coppicing (June), heavy shade.
(3) Dry season coppicing (November), light shade.
(4) Dry season coppicing (November), heavy shade.

Replanting

(1) Basket seedlings planted under shade in June.

Six .../

Six replicates of each treatment are being laid down in plots of about 16 trees. All trees in the experiments have been scored for capsid damage and Calonectria infection.

Persistence of Insecticides

Using Tribolium castaneum Hbst. as a test insect, assays of the persistence of DDT deposits on seedling cacao under light and heavy shade are now being made.

(b) Protection of Young Bearing Trees

The Spray-painting Trial at Nankesi is regarded as being completed and a final report is being compiled.

Many trees have now grown beyond spray-painting and are mist-blown with 5% DDT aqueous emulsion in the DDT Blocks and with 0.2% γ-BHC aqueous emulsion in the BHC Blocks. It is intended to continue treatment as a routine measure until the trees have grown to a closed canopy.

A special nozzle for the technique has been designed and proved successful on test. With the original nozzle five components had to be removed for cleaning but it is only necessary to remove two from the new nozzle.

(e) Combined Cultural and Insecticidal Control

Application of DDT as liquid or dust, together with removal of leading chupons where appropriate, has continued on those experiments already laid down at Tafo and Akwadum. A further experiment, designed to investigate inter alia the optimum age at which to introduce less frequent insecticidal applications has been laid down at Bunso with the assistance of the staff of the Department of Agriculture. The possibility of reducing the frequency of dusting from fortnightly to monthly application is being tested. A comparison is to be made between the bi-monthly applications of liquid DDT as preferred by the Department of Agriculture and the four-monthly application used by W.A.C.R.I. These investigations will take place on pruned and unpruned trees. The area of land made available by the Department of Agriculture for this experiment is planted with two year-old seedling Amelonado cocoa and is ten acres in extent. Large plots are being used to allow wide discards which should avoid the effects of drifting dust. Because of large plots and the large number of treatment combinations (20) leading to large blocks, an incomplete block design has been adopted. As in the other experiments the results are being assessed by fortnightly counts of damaged shoots removed, counts of capsids seen on sample trees and the yield in pods per tree when the cocoa comes into bearing. The treatments were commenced in June of this year.

The number of capsids seen during fortnightly inspections on the Tafo and Akwadum experiments have been recorded together with the totals of damaged shoots removed. At Akwadum only six capsids have been seen on the whole of the experiment (four acres) since the beginning of March and therefore no treatment comparisons can be made. At Tafo from March 17th to June 28th there has been an average of 10 damaged shoots removed from 100 trees at each visit. There is again a suggestion that rather more shoots are being removed from dusted trees than from spray-painted trees (12.5 per 100 trees per visit for the former against 7.5 for the latter).

However .../

However, the incidence of damage is generally low and all treatments must be considered effective at this stage. Similarly a low capsid population of 3.3 bugs per 100 trees per visit has been encountered, and there is as yet no indication of the greater efficacy of liquid or dust application in maintaining this low population.

(f) Ecological Studies on the Capsid Population

Capsid Reproduction

Plots of seedling and intermediate cacao set aside for these studies have now become naturally infested and regular observations are in progress. So far, no eggs have been found on undamaged shoots suggesting that feeding on a shoot always precedes oviposition.

5. EXPERIMENTS ON ESTABLISHMENT AND MAINTENANCE

(a) Establishment Trials

(i) All establishment experiments using seedling material have been on a maintenance basis, routine brushing, harvesting of off-season pods and application of DDT having been carried out, and no yield or growth comparisons have been made.

(ii) Consideration is being given to the design and layout of experiments to elucidate the optimum conditions for planting of clonal material with respect to age, early shade treatments and irrigation.

(b) Spacing Trials

(i) In the Amelonado Spacing Experiment the incidence of capsid damage was found to be higher in widely spaced trees than in closely spaced trees (32.4% damaged trees at 200-400 trees per acre; 7.9% damaged trees at 1,200-2,800 trees per acre; Annual Report WACRI 1954-5). It was pointed out that the cost of prophylactic DDT treatment was unlikely to be proportionate to these percentages. A small costing trial was carried out using sample plots of 16 trees and 1 gallon 'Mysto' sprayers with 3' lances. Table I shows the results in terms of pence per acre, assuming that a man hour costs 6d (no provision for supervision) and 1 gallon of 25% DDT emulsion costs 18/2d. The emulsion was diluted to 1¼% before use, and the amount of this dilute emulsion used in spray-painting the 16-tree plots was determined by weighing the machines before and after. A suitable process of randomisation was adopted to eliminate differences due to operators.

TABLE I .../

TABLE I

Cost of Single Application of DDT Emulsion on Eight-year old Amelonado Cocoa at Various Tree Densities

Trees per Acre	192	302	436	774	968	1210	1742	2722
DDT/Acre (pence)	9.6	19.3	19.9	34.2	48.9	39.9	50.2	86.0
Labour/Acre (pence)	23.5	37.2	57.8	97.4	120.1	127.5	186.6	296.4
Cost/Acre (pence)	33.1	56.5	71.7	131.6	169.0	167.4	236.8	382.4
DDT/1000 trees (pence)	50.0	63.8	45.6	44.2	50.5	33.0	28.8	31.6
Labour/1000 trees (pence)	122.3	123.2	118.8	125.9	124.1	105.4	107.1	108.9
Cost/1000 trees (pence)	172.3	187.0	164.4	170.1	174.6	138.4	135.9	140.5

It is seen that both DDT and labour costs per 1,000 trees are virtually constant for densities from 200-1,000 trees per acre with a marked drop at 1,200 trees per acre. At this point the capsid damage had been observed to be less intense, and it coincides with the density at which the cocoa canopy is now fully closed. The effect of this on the tree is to cause self-pruning of the lower branches and with the restricted height range of the 3' lances there was considerably less plant material within reach on which to apply the DDT and hence the lower cost. In terms of cost per acre this lower cost per tree is not however sufficiently low to offset the increasing number of trees, and total cost per acre rises rapidly after a density of 1,200 trees has been reached. This is important because it has already been shown that in this particular experiment yield per acre is lower at the high densities, and with the increased cost of a single application (at least three of which are required during the year) the profitability of high densities at this age becomes a doubtful proposition. No opportunity has yet arisen for a costing study of weeding in this experiment, but it will be undertaken as soon as practicable. It is considered likely that the cost of weeding will become negligible in the region of 600 trees per acre, and a tentative estimate at the optimum economic density may be put at 500 trees per acre.

(ii) A similar trial to determine the cost of spray-painting six-year old trees in the Upper Amazon Spacing and Pruning Experiment was also carried out using sample plots of 25 trees. The density range is from 302 to 680 trees per acre and the trees on half of the plots have had their vertical growth stopped at the first jorquette. Generally speaking the cost per 1,000 trees is constant at an average of 204.9 pence which compares quite favourably with that of 173.8 pence per 1,000 trees for Amelonado at approximately the same densities, when the greater vegetative growth of the Amazon cocoa is taken into consideration. On an acreage basis there is a corresponding decrease in cost with decreasing density. The highest

yield .../

yield per acre during the 1954-5 crop year was shown by the closely planted plots in this experiment and it is of interest to compare this with the increased cost of DDT application on such plots together with the corresponding comparison on more widely spaced plots.

TABLE II

Cost of DDT Application Compared with Gross Return per Acre (Upper Amazon Cocoa)

Tree Density per Acre and Spacing	302 (12' x 12')	436 (10' x 10')	680 (8' x 8')
Value of gross yield 1954-5 *	295/11d	311/ 2d	350/10d
Cost of DDT applications (3/year)	14/ 6d	28/ 3d	35/ 8d
Residual value per acre	281/ 5d	287/11d	315/ 2d

* At 72/- per load of 60 lbs.

The matter requires further study including a consideration of overheads such as the cost of establishment which will vary with the tree density, particularly when basket seedlings are used, as in this experiment.

(iii) Further regression analyses have been made to determine the relationship between stand density and yield on recorded cocoa on the Institute's Old Station during the period 1938-1954. Regression coefficients have been calculated on a log-density/log.-yield per tree basis for each year, and for the same variables for the whole period. This analysis confirms the previous findings (Quarterly Report WACRI March 1955) that there is a decline in yield per tree with increasing stand density, but that this decline is insufficient to result in a decline in yields per acre.

(d) Comparative Yield Trials of Seedlings and Rooted Cuttings

No further planting of the required additional two replicates of this experiment has yet been possible because the Plant Breeders have been unable to supply hand pollinated seedling material owing to unfavourable flowering and pod-setting conditions early in the year.

(e) Effect of Soil Type on Pod Development and Yield

A number regression analyses have been made to determine the relationship between pods per tree, log. pods per tree and log. pods per acre on the one hand and organic carbon percentage, total nitrogen percentage and total exchangeable bases in the top two inches of the various soils on the other. No significant results either by single or multiple regression, have been demonstrated.

This .../

This result together with fact that soils hitherto regarded as "bad" cocoa soils have produced good yields during the four years 1951-4 (Annual Report WACRI 1954-5) strongly suggests that soil type per se may be misleading as an indication of its suitability for cocoa, and "bad" soils should not be condemned out of hand. In none of the four years under review has the annual rainfall been markedly low, a condition which is pre-supposed to lead to the demise of trees on "bad" cocoa soils. Graphs of the moisture content of the top six inches of the soils show that the valley bottom soils have retained as much and often more, water during the period March 1951 to May 1953 than have midslope and hilltop soils. Data available from the records of the Old Station will be used to compare yields from trees on the various soil types since 1938, a period which will include the very dry years of 1944 and 1946.

(f) Methods of Forecasting Yields of Cocoa

Recording for the current year has commenced. It has been necessary to discard a number of plots owing to loss of the bulk of the trees as a result of Swollen Shoot control measures and capsid attack. It was always the intention that sample plots should be managed in exactly the same way as the cocoa that they supposedly represent, and the loss of these plots is therefore taken to be a reflection of the changes occurring on the Square Mile in general, and no substitute plots will be sought.

(g) The Effect of Retention and Removal of Chupons on Rooted Fan Cuttings

Maintenance work consisting of keeping the cocoa lines open has been continued on this experiment which has now been in the field for a year. Vacancies reported earlier (Quarterly Report WACRI December 1954) have been filled. The original plants have a healthly appearance and further losses are unlikely.

Frequency of Picking Experiments

Harvesting schedules have been drawn up for the coming year for the experiments at Tafo and Kukua. An additional experiment has been laid down at Tafo to compare the yields from trees subjected to very frequent picking (3-day intervals) with those from which the pods will be picked at two-monthly intervals. This low frequency treatment is intended to approximate to that employed by cocoa farmers. Field staff have been instructed to act as though they were Gold Coast cocoa farmers and pick accordingly.

It has been reported earlier (Annual Report WACRI 1954-5) that an attempt was to be made to determine if the higher yields obtained from plots with a high frequency of picking could be attributed to the wider spacing in those plots. A rough survey of tree density has shown that it is fairly uniform. Although it has not been possible to carry out a critical analysis it seems unlikely that there is sufficient variation in the tree densities to account for the effects already noted.

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6. SOIL FERTILITY AND MANURIAL REQUIREMENTS

(a) Effect of Amounts and Combinations of Major Nutrients

(i) Routine fertilizer applications have been made on all existing trials. Height of seedling measurements have shown a small but significant response to superphosphate at Juaso. This and the response to superphosphate at Poanu previously reported are the only positive responses recorded to date.

Shade reduction has been continued on 3 blocks of the trials on Blocks A and H, W.A.C.R.I and Bunso, and has produced a marked increase in growth on the W.A.C.R.I. trials. No fertilizer responses have yet been observed on the lightly shaded blocks.

(ii) The first year's yield figures for these four experiments have been received from the Department of Agriculture and are being assessed.

(iii) The first year's yield-recording has been completed by the Department of Agriculture. A further year's pre-treatment yields will to be taken before fertilizers are applied.

(b) Effect of Different Sources of the Major Nutrients

The first year's yield figures for these two experiments have been received from the Department of Agriculture and are being assessed.

(g) Investigation of Factors Limiting Growth in the Early Life of Cacao Seedlings

The scope of this experiment has now been altered, and shade is being removed from two of the four blocks to study the responses to mineral fertilizers and mulch with and without shade. A sample of seedlings removed as thinnings showed that plants in the lightly shaded blocks had a 64% greater dry weight than those in normal shade. New flush leaves in the lightly shaded blocks are showing symptoms of what is believed to be a minor nutrient deficiency. Leaf injections are being carried out to try to diagnose this deficiency.

(h) Role of Minor Elements

Dressings of magnesium sulphate have been applied to cacao seedlings in microplots. A larger microplot experiment to test a range of minor elements has been planted but no treatment has been applied yet.

In the experiment on T12 trees to induce zinc deficiency with wood trash and to discover its effect on the tree with special reference to cherelle wilt, no deficiency has as yet shown up, 7 months after treatment was applied.

8. .../

8. PLANT BREEDING AND SELECTION

In the absence of the Plant Breeders, only routine maintenance work was done. No new research was carried out during the quarter.

(a) Established Trials

Brushing has been carried out in all the trials and the two clonal trials have been extensively pruned to encourage a higher canopy. Girth and height measurements are being taken in the 9th P.T.A.

(b) Breeding Programme

Pollinations are being continued for the Series II Variety Trials on cocoa stations. The first pods for these trials are now being delivered.

9. COCOA FERMENTATION AND QUALITY

(a) Work has been resumed on single pod fermentation and a new technique is being tried out.

A qualitative study of the polyphenols in cocoa has been undertaken preliminary to an investigation into the constitution of the purple beans which are found in fermented West African cocoa. It has been confirmed that the two principal coloured anthocyanins in fresh cocoa are a cyanidin monoglycoside and a cyanidin pentose glycoside. A trace of two other anthocyanins has been observed and these have been provisionally labelled cyanidin diglycosides from the results of an investigation of their partition coefficients.

12. PHYSIOLOGY OF NUTRITION, GROWTH AND FRUITING

(a) Studies of Root Growth

(i) Two 1-acre blocks of cacao on Koforidua and Akwadum soil series were planted with seed at stake in June. Observations and analyses of plant growth will be carried out for 4 years, with particular reference to the difference in root growth on these two different soil types. Plants will be dug up at monthly intervals for analysis.

(ii) Recording has begun in an experiment designed to test the effect of over-cropping in the first few years of growth on root growth and subsequent yield. Flowering is being prevented for varying lengths of time.

(e) Investigation of Cherelle Wilt

(i) An experiment has commenced in the 1st Clonal Trial to test the effect of various concentrations of α-naphthalene acetic acid (NAA) on cherelle wilt.

Concentrations .../

Concentrations of 50, 250 and 1,000 p.p.m. were used and although it is too early in the season to assess the overall effect it is obvious that 1,000 p.p.m. is toxic to pods. Workers in South America had recommended this concentration for the control of wilt. All wilted pods are measured in an attempt to see whether NAA is of value in preventing wilt in certain sizes of pods.

(ii) Last season's experiment on flush prevention is being repeated on a larger scale in the 2nd Clonal Trial. In addition to preventing flushing, (by mechanical removal of buds), flowers are removed on certain plots after a tree has reached its target of pods set. No results are yet available.

(iii) An analysis is being made of the factors influencing wilt, and subsequently yield, on 96 trees of ACU85, the highest yielding clone in the 1st Clonal Trial. As in the two experiments above, weekly counts are made of flowers, healthy and wilted pods and flushing.

(iv) Experiments are in progress to find the effect of ringing (removal of bark and phloem) of pod stalks on the incidence of wilt. Partial ringing causes a reduction in growth of the pod while complete ringing causes wilt within a few days.

13. STUDY OF THE EFFECTS OF "SHADE" IN CACAO CULTIVATION

(a) Fertilizer Treatments in Relation to Shade Conditions

An NPK trial on Amazon seedlings in pots is in progress in 50%, 80% and 100% light intensities. Growth in 50% light has so far been the best, but responses to P have been observed in 80% and 100% light.

(b) Effect of Forest Litter Removal

Routine litter removal has been continued, and has produced a marked depression in the growth rate of the seedlings. This depression is, to a large extent, offset by grass mulching.

(d) Comparison of Yields of Shaded and Unshaded Cacao

Four unshaded farms have been selected for yield recording by the Department of Agriculture and work will start on them in the forthcoming major crop.

IBADAN SUB-STATION

1. VIRUS RESEARCH

(a) Host Range Investigations

A survey of the parts of the British Cameroons where Cola chlamydantha was said to occur was undertaken in April. No. C. chlamydantha was seen and it appears that

this .../

this species had been confused with the related C. pachycarpa and C. lepidota which were common in the reserves visited. In the absence of C. chlamydantha attempts were made to transmit virus to cacao from other related digitately leaved species, but the test plants in this series of experiments have not been re-examined yet.

(b) Insect Transmission Studies

Infection occurred in one test plant used in the experiments previously reported in which Geococcus coffeae was tested as a vector of cocoa virus. Though this may have been due to the presence of a contaminant species of mealybug, the observation is being followed up by an intensive investigation of G. coffeae as a possible vector.

(c) Classification of Viruses and Virus Strains

The collection of isolates maintained at the Substation was extended during the quarter to include 5 newly collected from the vicinity of the original Asalu outbreak. One was found at the edge of the cut out area at Asalu, and the rest are collections from outbreaks involving one or two trees in 4 widely separated localities within a few miles of Asalu. These small outbreaks are separated by apparently healthy cocoa, and it seems likely from the very characteristic symptom pattern produced by the isolates that all have the same origin. The Asalu virus has never been transmitted other than by grafting, and this apparent discontinuity of its occurence is quite inexplicable on present knowledge.

Rate of Spread of Nigerian Isolates

Monthly observations on the number of trees showing symptoms in the Offa Igbo Observation Plot have been discontinued, but yield recording is still maintained here and at Korobeto.

(i) Coppicing Experiments

(a) The investigation of factors influencing the regeneration of cocoa trees after coppicing continues at INA Farm. Fourteen acres of the "Old Spacing Trial" have now been coppiced and the general condition of the regenerating chupons is excellent, though a few have been damaged by insect pests, particularly Tragocephala sp. The routine spraying of the whole area with DDT emulsion has prevented any significant capsid damage so far. One acre of the area has been handed over to the Cocoa Survey Division of the Department of Agriculture for investigations on the effect on the growth of chupons of mineral nutrients, applied to the soil and as sprays. It is hoped also to carry out a joint experiment with the Cocoa Survey Division on the effect of mulching on the growth of chupons on a further acre of the area.

(b) Part of the spacing trial at Owena Farm has now been coppiced in experiments being done by the Entomology Division of the Federal Department of Agricultural Research, to compare the yields of severely damaged trees which have been regenerated by coppicing or restored by treatment with insecticides. Members of the Substation staff are making observations on the regeneration of the coppiced part of the experiment for comparison with that of other areas.

(c) .../

(c) The use of coppicing as an adjunct to cutting out in swollen shoot control (Annual Report 1954-55) depends on the assumption that all infected trees will produce visibly affected chupons. To test this an experiment has been started at Araromi, 20 miles south of Ibadan, in which 1,200 trees in and round an outbreak of CSSV have been coppiced. About 140 of them showed symptoms before being cut down. Observations are being made to find out -

(i) if all trees known to be infected produce chupons with virus symptoms

(ii) how long it takes for all infections to be revealed on the chupons growing from cut stumps.

2. MEALYBUG STUDIES

Only one month of this quarter was spent by the Entomologist at the Substation before proceeding on leave and the time was occupied in writing up the results of the mealybug survey in Nigeria. As several references have to be checked in London the final draft is not yet completed.